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(54) Elastic shaft coupling apparatus

(57) An elastic plate member 7 is clamped between an input-side stopper plate 5 and an output-side stopper plate 6, the input-side stopper plate being secured to an input-side member A and the output-side stopper plate to an output-side member B. Tubular members 8 and collar members 11, into which respective tubular members are inserted, are interposed between the elastic plate member 7 and a flange portion 1 of input-side member A. The input-side member A and the output-side member B are elastically coupled in both the axial and circumferential directions. A tilting-restricting shaft 14 is formed on either the input-side or output-side stopper plate and engages in a hole 12 in a tilting-restricting member (C, Fig 1).

Fig. 2A

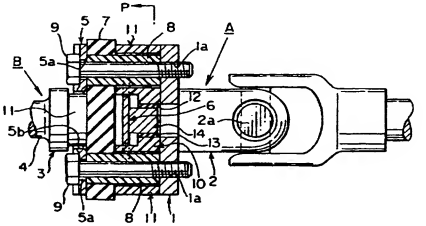

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Fig. 1

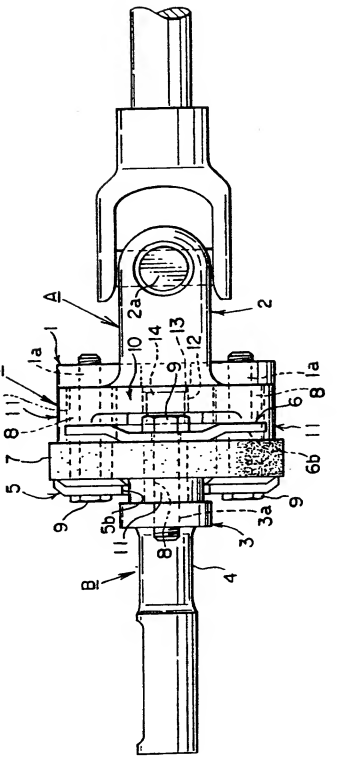


Fig. 2A

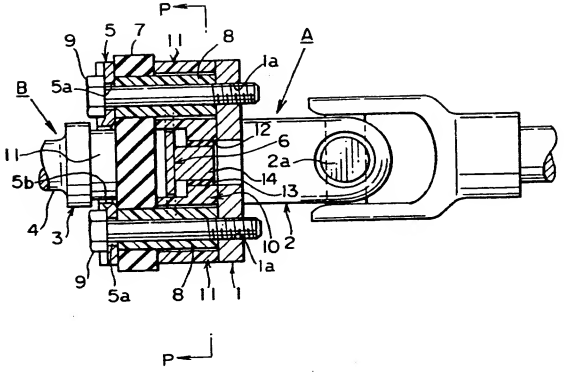
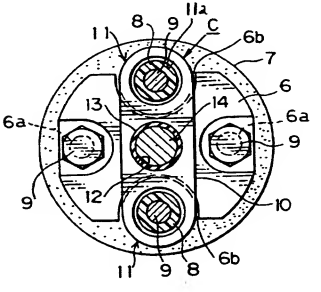

P
9
5
7
11
8
A
1a
B
5a
12
6
11
2a
5b
14
13
4
3
10
2
9
1a
5a
8
11
1
P

Fig. 2B


11a
11
8
9
C
6b
7
6
13
14
6a
6a
9
9
12
10
6b
11
9
8

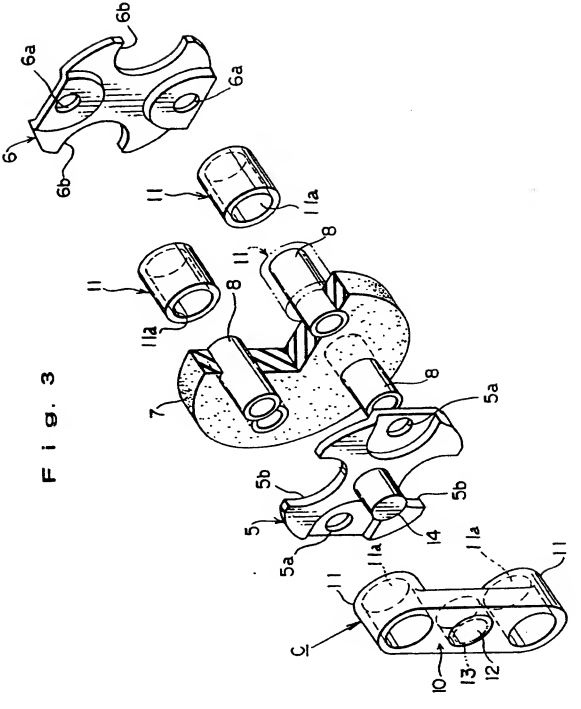


Fig. 3

Fig. 4

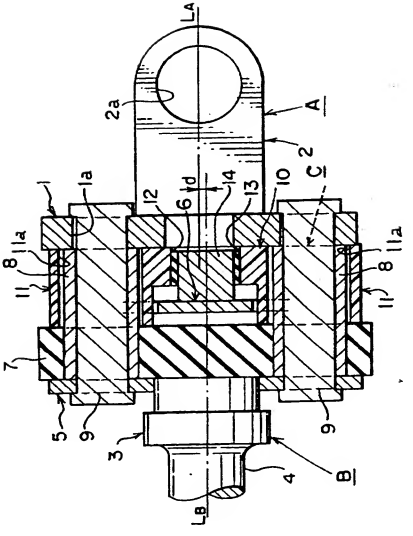


Fig. 5A

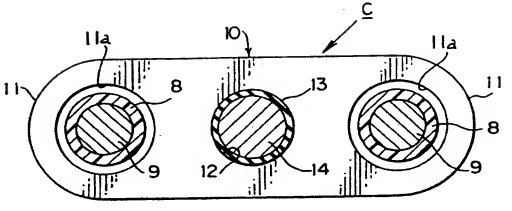

C
11a
10
11a
11
8
13
11
8
9
12
14
9

Fig. 5B

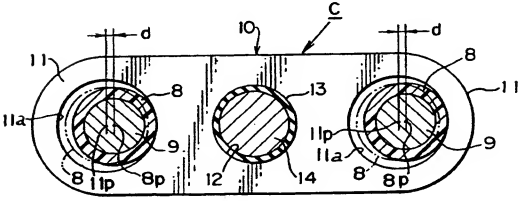

C
d
10
d
11
8
11a
8
13
11
9
11p
11a
9
8
11p
8p
12
14
8
8p

Fig. 6A

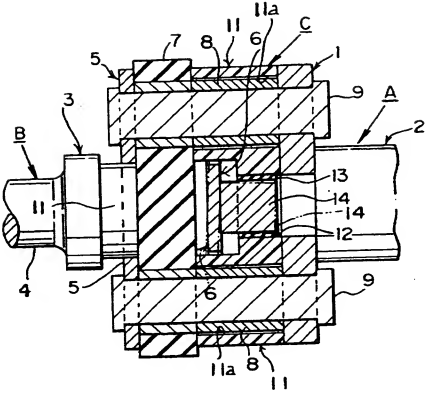

11a
C
7
8
11
6
1
5
9
A
3
2
B
13
11
14
14
12
4
5
6
9
11a
8
11

Fig. 6B

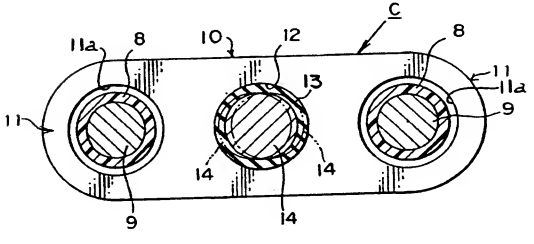

C
11a
8
10
12
8
11
11a
13
9
11
14
14
9
14

Fig. 7A

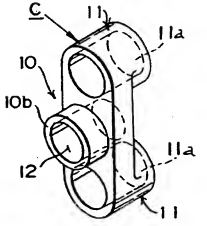


Fig. 7B

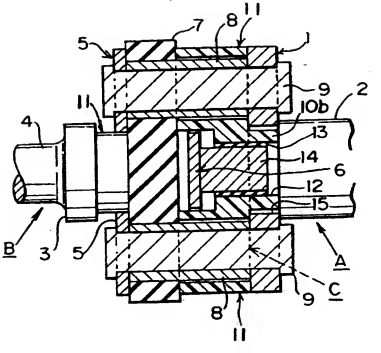


Fig. 8A

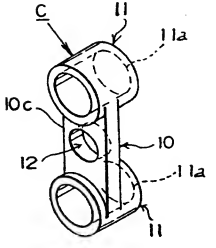


Fig. 8B

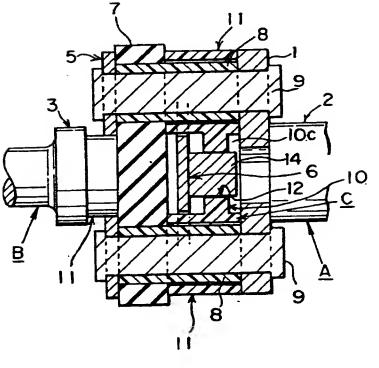


Fig. 9

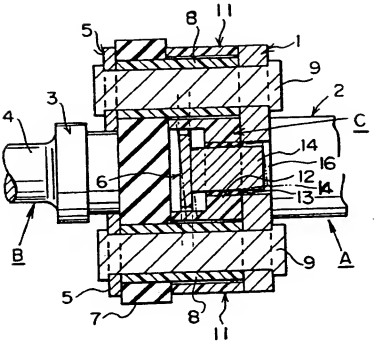


Fig. 10A

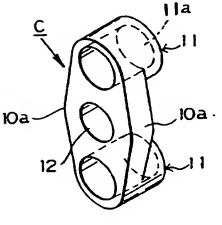


Fig. 10B

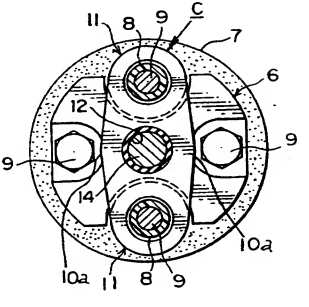


Fig. 11

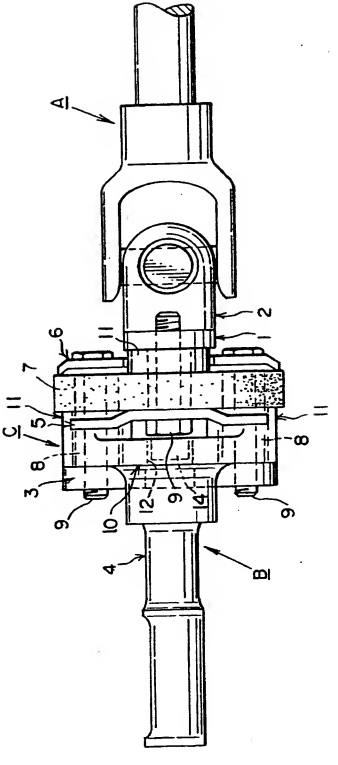


Fig. 12A

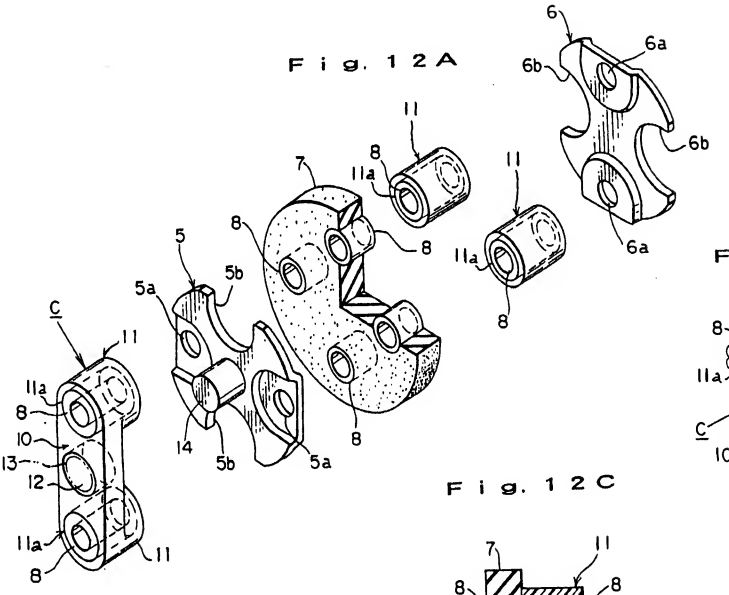


Fig. 12B

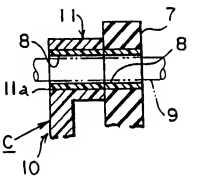


Fig. 12C

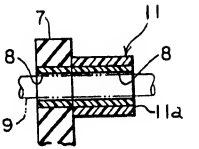


Fig. 13

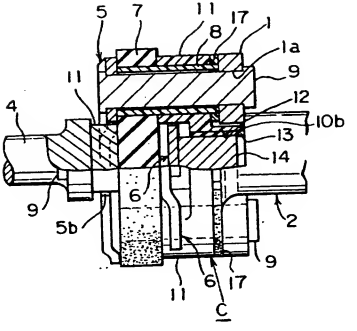


Fig. 14A

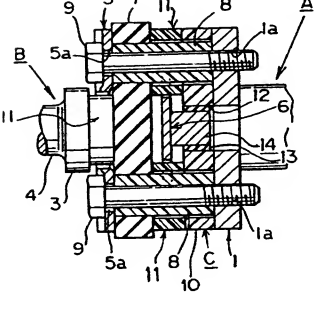


Fig. 14B

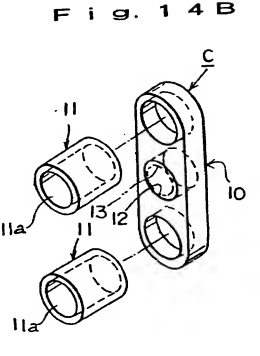


Fig. 15A

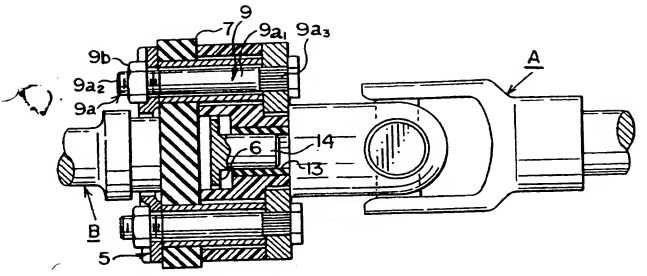


Fig. 15B

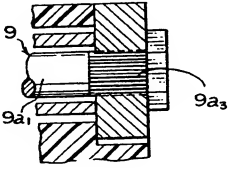


Fig. 15C

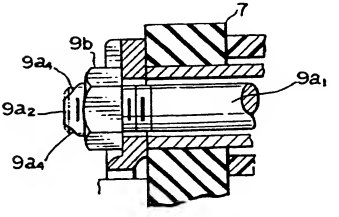
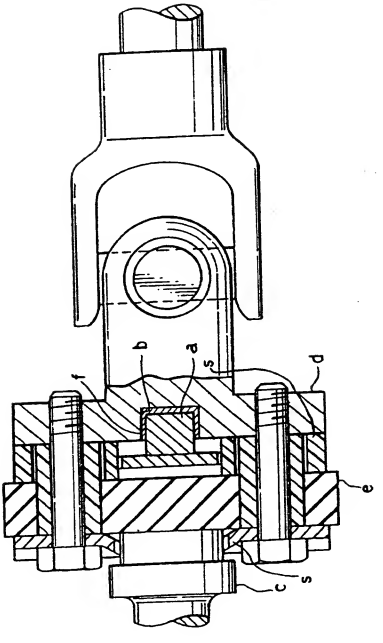


Fig. 16



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ELASTIC SHAFT COUPLING APPARATUS

The present invention relates to an elastic shaft coupling apparatus which is capable of elastically transmitting a rotating force from an input-side member to an output-side member, of improving the performance of isolating vibrations occurring during the transmission, and of favorably coping with the tilting (inclination) of the input-side member and the output-side member relative to each other with respect to the axial direction.

In a conventional steering system, an elastic shaft coupling apparatus having a mechanism for preventing the tilting of an input shaft and an output shaft of the elastic shaft coupling apparatus is disclosed in Japanese Patent Application Publication No. 75405/1992. To summarize the structure of the just-mentioned elastic shaft coupling apparatus, as shown in Fig. 16, a pair of stopper plates *s* are respectively disposed on both sides of an elastic plate member *e* in such a manner as to face axial end sides of an input shaft *c* and an output shaft *d*.

The stopper plate *s* and the input shaft *c* on one side, and the stopper plate *s* and the output shaft *d* on the other side, are pin coupled together by means of bolts, thereby coupling the input shaft *c* and the output shaft *d* with the elastic plate member *e* clamped therebetween.

In this elastic shaft coupling structure, appropriate gaps are respectively provided between the respective stopper plates *s* and the end faces of the input shaft *c* and the output shaft *d* corresponding thereto, and the input shaft *c* and the output shaft *d* are adapted to be rotatable relative to each other at an arbitrary rotating angle by virtue of deflection of the elastic plate member *e*. Further, a support shaft *a* is projectingly provided at a centre of either one of the stopper plates *s*, a receiving hole *b* for receiving the support shaft *a* is formed in an end face portion of the input shaft *c* or the output shaft *d* opposing that stopper plate *s*, and the support shaft *a* is inserted and disposed in the receiving hole *b* with an elastic material *f* disposed in the receiving hole *b* in such a manner as to surround the support shaft *a*.

If the above-described structure is adopted, there are cases where drawbacks can occur such as that, due to an error in the assembly of the support shaft *a* of the stopper plate *s* and the input shaft *c* or the output shaft *d*, their axes become offset, and that the poor positional accuracy of the support shaft *a* of the stopper plate *s* results in misalignment between the axes of the support shaft *a* and the input shaft *c* or the output shaft *d*.

In such a case, in an inserting and coupling section formed by the support shaft *a* of the stopper plate *s*, which is fixed to either the input shaft *c* or the output shaft *d*, and

the receiving hole *b* for receiving the support shaft *a*, the support shaft *a* of the stopper plate *s* is forcibly inserted in the receiving hole *b* due to the offset of the axes. As a result, the support shaft *a* of the stopper plate *s* and the receiving hole *b* are set in a mutually offset state, so that the support shaft *a* is set in a state of uneven contact with the elastic material *f* provided between the support shaft *a* and the inner peripheries of the receiving hole *b*.

Consequently, there occurs an increase in axial sliding resistance between the outer peripheral surface of the support shaft *a* of the stopper plate *s* and the elastic material *f* in the receiving hole *b*, which makes it impossible for the elastic plate member *e* to undergo smooth deflection in its axial direction. This also leads to the possibility of degrading the function of transmitting vibrations from the steering gear side to the steering shaft side while dampening the vibrations by means of the axial deflection of the elastic plate member *e*. Further, there is a possibility that variations in the amount of axial deflection of the elastic plate member *e* become large, and causing variations in the spring constant in individual elastic shaft coupling apparatuses and leading to instability in performance.

If a desired elastic shaft coupling apparatus is to be obtained which is capable of more substantially dampening the vibrations transmitted from the steering gear side to the

steering shaft side, the above-described drawbacks necessitates the provision of a structure which increases the spring constant of the elastic plate member *e* (i.e., makes deflection difficult to occur) in the direction of relative rotation of the input shaft *c* and the output shaft *d*, and lowers the spring constant in the axial direction, thereby facilitating the relative movement of the input shaft *c* and the output shaft *d* in the axial direction and stabilising their movement in the axial direction.

In addition, to realise such a structure, it is conceivably necessary to enhance parts processing accuracy or assembling accuracy, or enlarge the clearance between the outer periphery of the support shaft *a* of the stopper plate *s* and the elastic material *f* accommodated in the receiving hole *b*, so as to expand an allowable range of movement. However, the former measure increases the product cost, and the latter measure has the possibility of making it impossible to sufficiently display the function for preventing the tilting of the input shaft *c* and the output shaft *d* in the elastic shaft coupling apparatus.

In accordance with the present invention, there is provided an elastic shaft coupling apparatus comprising: an input-side stopper plate; an output-side stopper plate; an elastic plate member clamped by the input-side stopper plate and the output-side stopper plate; tubular members; collar members into which the tubular members are respectively inserted with clearances; an input-side member secured to the input-

side stopper plate at an appropriate interval therewith via the tubular members and the collar members; an output-side member secured to the output-side stopper plate at an appropriate interval therewith via the tubular members and the collar members, and elastically coupled to the input-side member in an axial direction and in a circumferential direction; a tilting-restricting shaft formed on one of the input-side stopper plate and the output-side stopper plate; and a tilting-restricting member fixed between the elastic plate member and one of the input-side member and the output-side member, and having a tilting-restricting hole for accommodating the tilting-restricting shaft therein. Accordingly, it is possible to satisfactorily restrict the tilting of the input-side member and the output-side member in the elastic coupling of the steering system, and improves the operating efficiency in assembling the apparatus.

The present invention will hereinafter be further described with reference to the accompanying drawings, in which:

Fig. 1 is a side elevational view of an elastic shaft coupling apparatus in accordance with an embodiment of the present invention;

Fig. 2A is a vertical side cross-sectional view of essential portions of the elastic shaft coupling apparatus in accordance with the present invention;

Fig. 2B is a cross-sectional view taken along in the

direction of arrows along line P - P in Fig. 2A;

Fig. 3 is an exploded perspective view of the essential portions in accordance with the present invention;

Fig. 4 is a vertical side cross-sectional view of the essential portions, and illustrates a state in which the axis of a tilting-restricting shaft and the centre of a tilting-restricting hole are aligned even though the axes of an input-side member and an output-side member are not aligned with each other;

Fig. 5A is a schematic diagram illustrating the positional relationships among the tilting-restricting shaft, tubular members, and shaft-shaped fixing means which are fitted in a tilting-restricting member in a state in which the axes of the input-side member and the output-side member are aligned with each other;

Fig. 5B is a schematic diagram illustrating the positional relationships among the tilting-restricting shaft, the tubular members, and the shaft-shaped fixing means which are fitted in the tilting-restricting member in a state in which the axes of the input-side member and the output-side member are not aligned with each other;

Fig. 6A is a vertical side cross-sectional view of the essential portions, and illustrates a state in which the tilting-restricting shaft is restored from its offset state with respect to the tilting-restricting hole;

Fig. 6B is a schematic plan view of the tilting-restricting member, and illustrates the state in which the tilting-restricting shaft is restored from its offset state with respect to the tilting-restricting hole;

Fig. 7A is a perspective view of a modification of the tilting-restricting member;

Fig. 7B is a vertical side cross-sectional view of the essential portions in which the tilting-restricting member shown in Fig. 7A is used;

Fig. 8A is a perspective view of another modification of the tilting-restricting member;

Fig. 8B is a vertical side cross-sectional view of the essential portions in which the tilting-restricting member shown in Fig. 8A is used;

Fig. 9 is a vertical side cross-sectional view of essential portions of the elastic shaft coupling apparatus in accordance with another embodiment of the present invention;

Fig. 10A is a perspective view of still another modification of the tilting-restricting member;

Fig. 10B is a vertical front cross-sectional view of the essential portions in which the tilting-restricting member shown in Fig. 10A is used;

Fig. 11 is a side elevational view of the elastic shaft coupling apparatus in accordance with still another embodiment of the present invention;

Fig. 12A is an exploded perspective view of the essential portions of the elastic shaft coupling apparatus in accordance with a further embodiment of the present invention;

Fig. 12B is a vertical side cross-sectional view of the tilting-restricting member and its associated parts shown in Fig. 12A;

Fig. 12C is a vertical side cross-sectional view of a collar member and its associated parts shown in Fig. 12A;

Fig. 13 is a side view, partly in section, of the essential portions of the elastic shaft coupling apparatus in accordance with a still further embodiment of the present invention;

Fig. 14A is a vertical side cross-sectional view of the essential portions in which a tilting-restricting member having separately formed collar members is used;

Fig. 14B is a perspective view of the tilting-restricting member having the separately formed collar members;

Fig. 15A is a fragmentary side view of the elastic shaft coupling apparatus in accordance with a further embodiment of the present invention;

Fig. 15B is an enlarged cross-sectional view of essential portions shown in Fig. 15A;

Fig. 15C is an enlarged cross-sectional view of other essential portions shown in Fig. 15B; and

Fig. 16 is a vertical side cross-sectional view illustrating the elastic shaft coupling apparatus in accordance

with the conventional art.

As shown in Figs. 1 and 2A, the elastic shaft coupling apparatus in accordance with the present invention has a coupling structure in which an input-side member A and an output-side member B are coupled together via an elastic plate member 7, such that the rotating force in the rotating force is transmitted via the elastic plate member 7, and the input-side member A and the output-side member B are coupled together elastically in the axial direction. As specific examples of the input-side member A and the output-side member B, it is possible to use shaft members which are formed as flange shaft members having flanges at their shaft ends, or shaft members formed as yoke members, or a combination thereof. In the case where the flange shaft member and the yoke member are used in combination, a flange portion, which opposes a flange portion of the flange shaft member, is integrally formed from a plate member at an end face of the yoke member by press working.

A forked portion 2 comprising two opposing arm portions is formed integrally on a flange portion 1 of the input-side member A, while a pair of cross-shaft bearing holes 2a are respectively formed in the arm portions of the forked portion 2 (see Figs. 1 and 2A). A pair of input-side coupling through holes 1a are formed in the flange portion 1. Meanwhile, the output-side member B has a flange portion 3 and an output shaft portion 4 which are formed integrally in the axial direction

(see Fig. 1). A pair of output-side coupling through holes 3a are formed in the flange portion 3 in such a manner as to be bilaterally symmetrical about the centre of the flange portion 3.

As shown in Fig. 3, an input-side stopper plate 5 has a substantially disc-shaped configuration, and has a pair of fixing through holes 5a which are formed bilaterally symmetrically about the centre of the input-side stopper plate 5. The fixing through holes 5a are for coupling the input-side stopper plate 5 to the input-side member A. Further, the input-side stopper plate 5 has a pair of passing-through portions 5b arranged in a direction perpendicular to a line connecting the fixing through holes 5a. Each of the passing-through portions 5b has a notched shape in which an outer peripheral portion of the input-side stopper plate 5 is cut off in a substantially C-shaped configuration.

Similarly, an output-side stopper plate 6 has a substantially disc-shaped configuration in the same way as the input-side stopper plate 5, and has a pair of fixing through holes 6a for coupling the output-side stopper plate 6 to the output-side member B. The pair of fixing through holes 6a are formed bilaterally symmetrically about the centre of the output-side stopper plate 6. Further, the output-side stopper plate 6 has a pair of passing-through portions 6b arranged in a direction perpendicular to a line connecting the fixing

through holes 6a. The fixing through holes 6a and the passing-through portions 6b have shapes substantially similar to those of the fixing through holes 5a and the passing-through portions 5b of the input-side stopper plate 5, respectively (see Fig. 3).

The elastic plate member 7 has the shape of a disc and is formed of an elastic material such as rubber. The elastic plate member 7 is clamped by the input-side stopper plate 5 and the output-side stopper plate 6. Specifically, the input-side stopper plate 5 abuts against one side surface of the elastic plate member 7, and is secured to the input-side flange portion 1 at an appropriate interval therewith by the use of tubular members 8, collar members 11, and shaft-shaped fixing means 9 such as bolts (see Figs. 1 ad 2A). The tubular members 8 are arranged on an appropriate circumference in the vicinities of the outer periphery of the elastic plate member 7 at equal intervals in such a manner as to be inserted in and project from the elastic plate member 7. Projecting portions of the tubular members 8 are respectively inserted in hollow portions 11a of the collar members 11 (see Figs. 2A, 2B, and 3).

Two of the tubular members 8 are each positioned between the fixing through hole 5a and the input-side coupling through hole 1a in the input-side member A. The input-side member A and the input-side stopper plate 5 are coupled together at an appropriate distance therebetween in a state in which two

shaft-shaped fixing means 9 are respectively passed through the two tubular members 8. Similarly, the output-side member B and the output-side stopper plate 6 are also coupled together by two tubular members 8 and two shaft-shaped fixing means 9 at an appropriate distance therebetween in the same way as the input-side member A and the input-side stopper plate 5.

The two tubular members 8 and the two collar members 11 for coupling the input-side member A and the input-side stopper plate 5 are loosely inserted in the passing-through portions 6b in the output-side stopper plate 6. Also, the two tubular members 8 and the two collar members 11 for coupling the output-side member B and the output-side stopper plate 6 are loosely inserted in the passing-though portions 5b in the input-side stopper plate 5 (see Figs. 2A, 2B, and 3).

As for the tubular members 8 which are passed through the elastic plate member 7, their portions projecting from the elastic plate member 7 are covered with the collar members 11. Namely, the tubular members 8 are respectively inserted in the hollow portions 11a of the collar members 11. The interval between the elastic plate member 7 and the input-side member A and the interval between the elastic plate member 7 and the output-side member B are fixedly set by the collar members 11, respectively.

As another example of the tubular members 8, an arrangement may be provided such that, as shown in Figs. 12A

to 12C, tubular members 8 each having the same axial length as the thickness of the elastic plate member 7 are inserted in the elastic plate member 7 to form one subassembly, and separate tubular members 8 each having the same axial length as that of the collar member 11 are inserted in the hollow portions 11a of the collar members 11 to form subassemblies on both sides of the elastic plate member 7. These subassemblies are combined in use so as to couple the input-side member A and the input-side stopper plate 5 as well as the output-side member B and the output-side stopper plate 6 while appropriately setting their intervals, respectively.

It should be noted that a metallic material may be used as the material of the tubular members 8, and a non-metallic material such as a synthetic resin or a hard rubber material may be used as the material of the collar members 11. Appropriate clearances are provided between the collar member 11 and the tubular member 8 and/or between the tubular member 8 and the shaft-shaped fixing means 9.

As shown in Fig. 15A, each of the shaft-shaped fixing means 9 as its first example is comprised of a combination of a bolt 9a and a nut 9b. The bolt 9a has a shank portion $9a_1$ where threads are not formed and a threaded portion $9a_2$ formed at a tip of the shank portion $9a_1$, and a knurled surface $9a_3$ is formed in a portion of the shank portion $9a_1$ in the vicinity of the bolt head. The diameter of the shank is set such that the shank

portion $9a_1$ of the bolt 9a can be inserted into each input-side coupling through hole 1a and each output-side coupling through hole 3a by a pressure-fitting means.

As the shank portions $9a_1$ of the bolts 9a are inserted into the input-side coupling through holes 1a and the output-side coupling through holes 3a in a pressure-fitted state, it is possible to improve the accuracy in assembling the input-side member A and the input-side stopper plate 5 and assembling the output-side member B and the output-side stopper plate 6.

Further, as shown in Fig. 15B, the knurled surface $9a_2$ makes the pressure-fitted state securer with respect to the input-side coupling through hole 1a and the output-side coupling through hole 3a, particularly prevents idle rotation of the shank portion $9a_1$, and makes the operation of tightening the nut 9b easier and more efficient. Further, as the nut 9b, it is preferable to use a self-locking nut, i.e., a nut having a mechanism for preventing the loosening of the tightened nut, but the nut 9b is not necessarily limited to the same.

By using the self-locking nut as the nut 9b, it is possible to prevent the nut 9b from coming off the bolt 9a, with the result that it is possible to make securer the coupling between the input-side member A and the input-side stopper plate 5 and the coupling between the output-side member B and the output-side stopper plate 6.

Further, after the nut 9b is tightened onto the bolt 9a, it is preferable to form a deformed portion $9a_4$ at an end face of the threaded portion $9a_2$ of the bolt 9a by means of caulking, but the deformed portion $9a_4$ may not necessarily be formed. In the event that a loosening occurs to the nut 9b, the nut 9b can be prevented from coming off as the deformed portion $9a_4$ is formed by caulking.

In a second example of the shaft-shaped fixing means 9, each shaft-shaped fixing means 9 is comprised of the bolt 9a alone. Internal threads are formed in an inner peripheral surface of the input-side coupling through hole 1a of the flange portion 1 and in an inner peripheral surface of the output-side coupling through hole 3a of the flange portion 3, and the shaft-shaped fixing means 9 constituted by the above bolts are able to threadedly engage with such internally threaded holes 1a and 3a (see Figs. 1, 2A, and 11).

Namely, in the above-described arrangement, the input-side stopper plate 5 is interposed between the output-side member B and the output-side stopper plate 6, while the output-side stopper plate 6 is interposed between the input-side member A and the input-side stopper plate 5. Further, the elastic plate member 7 is interposed between the input-side stopper plate 5 and the output-side stopper plate 6 (see Fig. 2A).

The input-side member A and the output-side member B are

elastically coupled to each other via the elastic plate member 7. When the rotating force is transmitted from the input-side member A to the output-side member B, if there is some resistance in the output-side member B, the elastic plate member 7 is elastically twisted in the rotating direction, and causes an offset in the angle of rotation, thereby preventing an excessive load from being applied to the input-side member A and the output-side member B. Similarly, even in a case where the input-side member A and the output-side member B undergo a change in the tilting angle in the axial direction, the elastic plate member 7 is elastically deflected, thereby preventing an excessive load from being applied to the input-side member A and the output-side member B.

The elastic plate member 7 itself has a restoring force, and when the elastic plate member 7 is relieved of its load after being twisted in the rotating direction or undergoing deflection, the elastic plate member 7 is capable of restoring its original shape. In addition, the collar members 11 rotatively move appropriately inside the passing-through portions 5b and 6b of the input- and output-side stopper plates 5 and 6. As a result, the collar members 11 abut against side surfaces of the passing-through portions 5b or 6b, preventing the elastic plate member 7 from being twisted further in the rotating direction.

As shown in Figs. 1 to 3, a tilting-restricting member C as its first type is comprised of a connecting portion 10 and

the two collar members 11, all of which are formed integrally. The structure of each of these collar members 11 is such that the tubular member 8 is inserted in the hollow portion 11a of the collar member 11, as described before. These collar members 11 serve to set the respective intervals between the elastic plate member 7 and the input-side member A and between the elastic plate member 7 and the output-side member B. Additionally, the collar members 11 constitute abutment portions (at their peripheral portions) with the inner peripheral surfaces of the passing-through portions 5b and 6b of the input- and output-side stopper plate 5 and 6. A tilting-restricting hole 12 is formed in a centre of the connecting portion 10.

In the case of the tilting-restricting member C which is formed of a non-metallic material such as a synthetic resin or a hard rubber material, it is possible to reduce the striking sound occurring when the input-side member A and the output-side member B undergo relative rotation through the torsional deflection of the elastic plate member 7, and the collar members 11 formed of the non-metallic material are brought into contact with the inner peripheral surfaces of the respective passing-through portions 5b and 6b formed in the input- and output-side stopper plates 5 and 6.

Further, a tilting-restricting shaft 14 is provided on either the input-side stopper plate 5 or the output-side stopper plate 6. Specifically, the tilting-restricting shaft 14 has

the shape of a pin shaft, and is formed at a centre of a side of the input-side stopper plate 5 or the output-side stopper plate 6. The tilting-restricting shaft 14 is adapted to be inserted and accommodated in the tilting-restricting hole 12. In the example shown in Figs. 1, 2A, and 2B, the tilting-restricting shaft 14 is formed at the centre of a side of the output-side stopper plate 6. In the example shown in Fig. 3, the tilting-restricting shaft 14 is formed at the centre of a side of the input-side stopper plate 5.

The tilting-restricting shaft 14 is fixedly secured at the centre of the side of the input-side stopper plate 5 or the output-side stopper plate 6 by a welding means. Alternatively, the tilting-restricting shaft 14 may be formed integrally at the centre of the side of the input-side stopper plate 5 or the output-side stopper plate 6 when the stopper plate 5 or 6 is press worked by using a metal plate as a material.

In the case where the tilting-restricting member C is formed of the non-metallic material such as a synthetic resin or a hard rubber material, the tilting-restricting shaft 14 is directly inserted and accommodated in the tilting-restricting hole 12 to provide a mechanism for preventing the tilting of the input-side member A and the output-side member B with respect to the axial direction. In addition, the tilting-restricting shaft 14 serves to prevent the input-side stopper plate 5 and the output-side stopper plate 6 from coming into contact with

their opposing collar members 11 and tubular members 8 due to the tilting of the input-side member A and the output-side member B with respect to the axial direction. Further, since no metallic contact takes place between the input- and output-side members A and B, it is possible to suppress the transmission of vibrations from the output-side member B (e.g., the steering gear side) to the input-side member A (e.g., the steering column side).

As a second type of the tilting-restricting member C, as shown in Figs. 2A, 2B, and 5A, the tilting-restricting member C is provided with an elastic member 13 which is formed of such as an elastic rubber material or an elastic synthetic resin, the elastic member 13 being provided between an inner periphery of the tilting-restricting hole 12 and an outer periphery of the tilting-restricting shaft 14. Specifically, the elastic member 13 has a hollow cylindrical shape, and is fitted in advance in the tilting-restricting hole 12. The elastic member 13 makes it possible to further enhance the effect of suppressing the transmission of vibrations from the output-side member B to the input-side member A. Incidentally, in the tilting-restricting member C, in a case where the connecting portion 10 and the collar members 11 are formed separately, and the connecting portion 10 is formed of a metallic material, the transmission of the vibrations can be similarly suppressed by providing the elastic member 13 between the inner periphery of the tilting-restricting

hole 12 and the outer periphery of the tilting-restricting shaft 14.

As a third type of the tilting-restricting member C, as shown in Fig. 10A, the tilting-restricting member C is provided with a pair of enlarged width portions 10a which are provided on both sides of the longitudinally centre portion of the connecting portion 10, i.e., on both sides of the tilting-restricting hole 12. The enlarged width portions 10a make it possible to increase the area of that portion of the connecting portion 10 which surrounds the tilting-restricting hole 12, and increase areas of portions surrounding the two collar members 11. The enlarged width portions 10a allow the tilting-restricting member C to abut against the input-side member A or the output-side member B with a greater area by virtue of the provision of such a shape, so that it is possible to prevent the tilting of the tilting-restricting shaft 14 more reliably (see Fig. 10B).

As a fourth type of the tilting-restricting member C, as shown in Fig. 7A, the tilting-restricting member C is provided with a projecting tubular portion 10b which is formed in such a manner as to project from a peripheral edge of the tilting-restricting hole 12 in the connecting portion 10. In the tilting-restricting member C of this fourth type, as shown in Fig. 7B, the projecting tubular portion 10b is loosely inserted in a recess 15 formed in an axially centre portion of

the flange portion 1 of the input-side member A or the flange portion 3 of the output-side member B, in such a manner as to be slidable inside the recess 15. By forming this projecting tubular portion 10b, the axial length of the tilting-restricting hole 12 can be enlarged, and the wall thickness of the outer peripheral portion of the tilting-restricting hole 12 can be enlarged, thereby making it possible to increase the strength of the tilting-restricting member C.

For this reason, it is possible to obtain a large contact surface along the axial direction between the inner peripheral surface of the tilting-restricting hole 12 and the outer periphery of the tilting-restricting shaft 14 provided on either the input-side stopper plate 5 or the output-side stopper plate 6. Consequently, the tilting-restricting shaft 14 can be reliably held in the tilting-restricting hole 12, and the tilting of the input-side member A and the output-side member B with respect to the axial direction can be prevented.

As a fifth type of the tilting-restricting member C, as shown in Fig. 8A, the tilting-restricting member C is provided with an escape portion 10c which is formed around the tilting-restricting hole 12 as a recessed flat portion between axial ends of the two collar members 11 in the connecting portion 10 facing the end face of either the input-side member A or the output-side member B. As the tilting-restricting member C is thus formed, the tilting-restricting member C clamped between

the elastic plate member 7 and the end face of either the input-side member A or the output-side member B is able to cause the tightening force exerted by the shaft-shaped fixing means 9 to be applied only to the collar members 11 (see Fig. 8B).

For this reason, even if the recessed flat surface of the connecting portion 10 of the tilting-restricting member C and the end face of the input-side member A or the output-side member B have irregularities in their surfaces, only the collar members 11 come into contact with the end face of the input-side member A or the output-side member B, and the connecting portion 10 does not abut against such an irregular surface. Hence, it is possible to prevent the deformation of the inner peripheral surface of the tilting-restricting hole 12 in the tilting-restricting member C, and it is possible to avoid an external force which may be otherwise applied to the inner peripheral surface of the tilting-restricting hole 12 during assembly.

The arrangement provided is such that the end face of the input-side member A or the output-side member B opposing the tilting-restricting hole 12 in the tilting-restricting member C is formed as a flat surface, and the recessed escape portion 10c which is larger than the tilting-restricting hole 12 is formed (see Fig. 8B). On the other hand, in a case where the flat portion of the tilting-restricting member C which faces the end face of the input-side member A or the output-side member B is not provided with the recessed escape portion 10c, a hole

larger than the tilting-restricting hole 12 may be formed in an end face portion of the input-side member A or the output-side member B.

Namely, as shown in Fig. 9, a receiving hole 16 having a diameter larger than that of the tilting-restricting hole 12 is formed in the end face portion of the input-side member A or the output-side member B. The arrangement provided is such that the tilting-restricting shaft 14 formed on either the input-side stopper plate 5 or the output-side stopper plate 6 is inserted through the tilting-restricting hole 12 of the tilting-restricting member C, and a distal end portion of the tilting-restricting shaft 14 is received in the receiving hole 16. Thus the tilting of the input-side member A and the output-side member B with respect to the axial direction is first prevented by the inner peripheral surface of the tilting-restricting hole 12.

Then, in a case where an excessive bending load is applied to the tilting-restricting shaft 14, the inner peripheral surface of the tilting-restricting hole 12 or the rubber-made elastic member 13 provided on its inner periphery can be deformed by the tilting-restricting shaft 14, so that the tilting-restricting shaft 14 tends to be substantially inclined inside the tilting-restricting hole 12. Such a state can be prevented by the stopper mechanism wherein the inner peripheral surface of the receiving hole 16 formed in the input-side member A or

the output-side member B and the outer peripheral surface of the distal end portion of the tilting-restricting shaft 14 abut against each other.

Further, as a sixth type of the tilting-restricting member C, as shown in Figs. 14A and 14B, the connecting portion 10 and the collar members 11 are formed separately by using different materials, the connecting portion 10 being formed of a metallic material and the collar members 11 being formed of a resin material.

Although, in the above-described embodiments, a description has been given of the example in which the tilting-restricting member C is interposed between the input-side member A and the elastic plate member 7, an arrangement may be provided such that the tilting-restricting member C is interposed between the output-side member B and the elastic plate member 7, as shown in Fig. 11.

In still another embodiment, as shown in Fig. 13, a pair of annular elastic members 17 each formed in the shape of a facing plate are interposed between the end face of the tilting-restricting member C and the input-side member A or the output-side member B opposing that end face. Specifically, the annular elastic members 17 are disposed in such a manner as to be fitted over the respective tubular members 8. Since such a structure is adopted, it is possible to improve the capability of dampening vibrations in the transmission of vibrations

between the output-side member B and the input-side member A.

To sum up the basic arrangement of the above-described elastic shaft coupling apparatus in accordance with the present invention, the elastic shaft coupling apparatus comprises: the input-side stopper plate 5; the output-side stopper plate 6; the elastic plate member 7 clamped by the input-side stopper plate 5 and the output-side stopper plate 6; the tubular members 8; the collar members 11 into which the tubular members 8 are respectively inserted with clearances; the input-side member A secured to the input-side stopper plate 5 at an appropriate interval therewith via the tubular members 8 and the collar members 11; the output-side member B secured to the output-side stopper plate 6 at an appropriate interval therewith via the tubular members 8 and the collar members 11, and elastically coupled to the input-side member A in an axial direction and in a circumferential direction; the tilting-restricting shaft 14 formed on one of the input-side stopper plate 5 and the output-side stopper plate 6; and the tilting-restricting member C fixed between the elastic plate member 7 and one of the input-side member A and the output-side member B, and having the tilting-restricting hole 12 for accommodating the tilting-restricting shaft 14 therein. Accordingly, first of all, there is an advantage in that even if axes L_A and L_B of the input-side member A and the output-side member B are offset from each other (see Fig. 4), it is possible to constantly maintain

the tilting-restricting member C and the tilting-restricting shaft 14 in proper states. Secondly, an advantage can be obtained in that the structure can be simplified.

To give a detailed description of the above advantages, the present invention does not adopt the conventional structure in which the tilting-restricting shaft 14 provided on either the input-side stopper plate 5 or the output-side stopper plate 6 is inserted into the input-side member A or the output-side member B itself. Instead, the present invention adopts a structure in which the tilting-restricting shaft 14 provided on either the input-side stopper plate 5 or the output-side stopper plate 6 is accommodated in the tilting-restricting hole 12 of the tilting-restricting member C provided between the elastic plate member 7 and one of the input-side member A and the output-side member B. By making use of the clearances each provided between the collar member 11 and the tubular member 8 and/or between the tubular member 8 and the shaft-shaped fixing means 9, the tilting-restricting member C can be moved in a direction perpendicular to the axial direction independently of the input-side member A or the output-side member B.

Therefore, as shown in Fig. 4, a situation is now assumed to have occurred in which the axis L_A and the axis L_B are offset from each other due to an error in assembly of the tilting-restricting shaft 14 of the stopper plate and the input-side member A or the output-side B, and that an offset with a gap

of a dimension *d* has occurred therebetween, degrading the positional accuracy of the tilting-restricting shaft 14 of the stopper plate. Even in such a case, in accordance with the present invention, since the tilting-restricting member C is provided separately from the input-side member A and the output-side member B, the tilting-restricting member C can be moved in a direction perpendicular to the axial direction within the range of the clearance.

Namely, as shown in Fig. 5B, positional adjustment of the tilting-restricting shaft 14 in the tilting-restricting hole 12 becomes possible simply by moving the respective tubular members 8 by an amount of the dimension *d* such that the axial centre 8p of each tubular member 8 becomes aligned with the axial centre 11p of the hollow portion 11a of each collar member 11 in the tilting-restricting C. Hence, within the allowable range of adjustment, the axis of the tilting-restricting shaft 14 can be aligned with the centre of the tilting-restricting hole 12.

As a result, it is possible to overcome the state of uneven contact between the outer peripheral surface of the tilting-restricting shaft 14 and the inner peripheral surface of the tilting-restricting hole 12, so that it is possible to make smooth the sliding of the tilting-restricting shaft 14 in the tilting-restricting hole 12 due to the axial deflection of the elastic plate member 7 serving as an elastic shaft coupling. Accordingly, it is possible to cause the vibrations-damping

effect to be exhibited sufficiently with a predetermined spring constant without hampering the axial deflection of the elastic plate member 7, thereby making it possible to stabilise the performance of the apparatus.

In accordance with the present invention, since the positional adjustment of the tilting-restricting shaft 14 can be made through the adjustment of clearances between the collar member 11 and the tubular member 8 and/or between the tubular member 8 and the shaft-shaped fixing means 9 in the respective insertion hole, the tilting-restricting shaft 14 can be inserted and accommodated in the tilting-restricting hole 12 in a coaxial neutral state without enlarging the clearance between the outer peripheral surface of the tilting-restricting shaft 14 and the inner peripheral surface of the tilting-restricting hole 12 or without increasing parts processing accuracy and assembling accuracy. Therefore, the mechanism for preventing the tilting of the input-side member A and the output-side member B is able to sufficiently demonstrate its performance without increasing the product cost.

Further, if, as described above, the elastic shaft coupling apparatus is arranged to further comprise the hollow cylindrical elastic member 13 interposed between the inner peripheral surface of the tilting-restricting hole 12 in the tilting-restricting member C and the outer peripheral surface of the tilting-restricting shaft 14, in addition to the

aforementioned advantages, it is possible to expect a greater effect of the tilting-restricting shaft 14 in dampening vibrations by means of the elastic member 13. In addition, even if the tilting-restricting shaft 14 becomes tilted with respect to the axial direction of the tilting-restricting hole 12, the tilting-restricting shaft 14 is forcibly pushed back owing to the restoring property of the elastic member 13 in such a way that the axial centre of the tilting-restricting shaft 14 is aligned again with the axial centre of the tilting-restricting hole 12. Hence, the performance of correcting the tilting of the tilting-restricting shaft 14 improves.

Further, if, as described above, in the elastic shaft coupling apparatus, the tilting-restricting member C and the collar members 11 are integrally formed of a synthetic resin, when the collar members 11 of the tilting-restricting member C and the like come into contact with the input-side stopper plate 5 or the output-side stopper plate 6, metallic contact can be avoided virtually completely, thereby making it possible to reduce the contact noise sufficiently. In addition, since the two collar members 11 are integrally formed with the tilting-restricting member C, the number of component parts used can be substantially reduced, which in turn reduces the number of assembling steps, improves productivity, and lowers the product cost.

Further, if, as described above, the elastic shaft

coupling apparatus is arranged to further comprise the projecting tubular portion 10b formed in such a manner as to project from a peripheral edge of the tilting-restricting hole 12 of the tilting-restricting member C and accommodated in the recess 15 formed in an end face portion of one of the input-side member A and the output-side member B, the axial length of the tilting-restricting hole 12 can be increased by the formation of the tubular portion 10b. Hence, the wall thickness of the outer peripheral portion of the tilting-restricting hole 12 can be enlarged, thereby making it possible to increase the strength of the tilting-restricting member C.

For this reason, it is possible to obtain a large contact area along the axial direction between the inner peripheral surface of the tilting-restricting hole 12 and the outer periphery of the tilting-restricting shaft 14 provided on either the input-side stopper plate 5 or the output-side stopper plate 6. Consequently, the tilting-restricting shaft 14 can be reliably held in the tilting-restricting hole 12, and the tilting of the input-side member A and the output-side member B with respect to the axial direction can be prevented.

Further, if, as described above, in the elastic shaft coupling apparatus, the tilting-restricting shaft 14 accommodated in the tilting-restricting hole 12 of the tilting-restricting member C has its distal end portion received in the receiving hole 16 having a diameter larger than that of

the tilting-restricting hole 12 and formed in an end face portion of one of the input-side member A and the output-side member B, the inner peripheral surface of the receiving hole 16 serves as a stopper for restricting the tilting of the tilting-restricting shaft 14.

Namely, in a case where an excessive bending load is applied to the tilting-restricting shaft 14 in the tilting-restricting hole 12, the tilting-restricting shaft 14 which is thereby tilted strongly abuts against the inner peripheral surface of the tilting-restricting hole 12, causing deformation of the inner peripheral surface of the tilting-restricting hole 12. Alternatively, the elastic member 13 which is provided in the tilting-restricting hole 12 may become deformed substantially.

In such a case, a large inclining force of the tilting-restricting shaft 14 inside the tilting-restricting hole 12 is received by the inner peripheral surface of the receiving hole 16 formed in the input-side member A or the output-side member B as the inner peripheral surface of the receiving hole 16 abuts against the outer peripheral surface of the distal end of the tilting-restricting shaft 14. Accordingly, it is possible to prevent the deformation of the inner peripheral surface of the tilting-restricting hole 12 and protect the elastic member 13.

Further, if, as described above, the elastic shaft

coupling apparatus is arranged to further comprise the facing plate-shaped elastic member 17 interposed between an end face of the tilting-restricting member C and one of the input-side member A and the output-side member B opposing that end face, it is possible to improve the capability of dampening vibrations in the transmission of vibrations through the facing plate-shaped elastic member 17 interposed between contact surfaces of the tilting-restricting member C and the input-side member A or the output-side member B.

CLAIMS:

1. An elastic shaft coupling apparatus comprising:

an input-side stopper plate;

an output-side stopper plate;

an elastic plate member clamped by said input-side stopper plate and said output-side stopper plate;

tubular members;

collar members into which said tubular members are respectively inserted with clearances;

an input-side member secured to said input-side stopper plate at an appropriate interval therewith via said tubular members and said collar members;

an output-side member secured to said output-side stopper plate at an appropriate interval therewith via said tubular members and said collar members, and elastically coupled to said input-side member in an axial direction and in a circumferential direction;

a tilting-restricting shaft formed on one of said input-side stopper plate and said output-side stopper plate; and

a tilting-restricting member fixed between said elastic plate member and one of said input-side member and said output-side member, and having a tilting-restricting hole for accommodating said tilting-restricting shaft therein.

2. An elastic shaft coupling apparatus according to Claim 1, further comprising:

a hollow cylindrical elastic member interposed between an inner peripheral surface of said tilting-restricting hole in said tilting-restricting member and an outer peripheral surface of said tilting-restricting shaft.

3. An elastic shaft coupling apparatus according to Claim 1 or claim 2, wherein said tilting-restricting member and said collar members are integrally formed of a synthetic resin.

4. An elastic shaft coupling apparatus according to any of the preceding claims, further comprising:

a projecting tubular portion formed in such a manner as to project from a peripheral edge of said tilting-restricting hole of said tilting-restricting member and accommodated in a recess formed in an end face portion of one of said input-side member and said output-side member.

5. An elastic shaft coupling apparatus according to any of the preceding claims,

wherein said tilting-restricting shaft accommodated in said tilting-restricting hole of said tilting-restricting member has a distal end portion received in a receiving hole having a diameter larger than that of said tilting-restricting hole and

formed in an end face portion of one of said input-side member and said output-side member.

6. An elastic shaft coupling apparatus according to any of the preceding claims, further comprising:

a facing plate-shaped elastic member interposed between an end face of said tilting-restricting member and one of said input-side member and said output-side member opposing that end face.

7. An elastic shaft coupling apparatus substantially as hereinbefore described with reference to any of the examples shown in Figures 1 to 15 of the accompanying drawings.

The Patent Office

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Application No: GB 9707317.5 **Examiner:** C J Duff
Claims searched: 1 - 7 **Date of search:** 26 June 1997

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2U

Int Cl (Ed.6): B62D, F16D

Other: On-line: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 1498739	(RUSTON-BUCYRUS) Whole document	
A	EP 0194184 A1	(FUJI) Whole document	
A	US 5222913	(NAGASHIMA) Whole document	

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